Education and Human Development Journal
Tahun 2022; Vol. 7 (3); ISSN. 2541-0156; e-SSN. 2599-0292; hal. 57-63
https://journal2.unusa.ac.id/index.php/EHDJ/index
doi : 10.33086/ehdj.v7i3

Mastery Level of Basic Concept of Science Course Using STEM-PBL based PHET Simulation Application

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Abstract: This study aims to determine the effectiveness of using the Phet Simulation application based on STEM (Science, Technology, Engineering, and Mathematics) – PBL (Problem Based Learning) for mastering the basic concepts of science, especially the subject of Dynamic Electricity. This research was conducted on 1st Semester students from one of the PTKIS in Lamongan who taught the basic science concepts course for the 2022/2023 academic year, namely 35 people. The type of research used is quasi-experimental with a One Group Pretest-Posttest research design. The data collection techniques as the main data are pretest and posttest to find out the increase in mastery of the concept. The hypothesis testing in this study used the Paired Sample t Test using the SPSS 25 application. Based on the data obtained sig.2tailed 0.000 <0.05, it can be concluded that the use of the Phet Simulation application based on STEM-PBL is effective in increasing students' understanding of concepts.

Keywords: Mastery of Concepts; Phet Simulation; STEM-PBL

Abstrak: Penelitian ini bertujuan untuk mengetahui efektivitas penggunaan aplikasi *Phet Simulation* berbasis STEM (*Science, Technology, Engineering, and Mathematics*) – PBL (*Problem Based Learning*) terhadap penguasaan konsep mata kuliah konsep dasar IPA khususnya materi Listrik Dinamis. Penelitian ini dilaksanakan pada mahasiswa semester 1 dari salah satu PTKIS di Lamongan yang mengampu mata kuliah konsep dasar IPA tahun akademik 2022/2023 yakni sebanyak 35 orang. Jenis penelitian yang digunakan quasi eksperimen dengan desain penelitian *One Group Pretest-Posttest design*. Adapun teknik pengumpulan data sebagai data utama yakni *pretest* dan *posttest* untuk mengetahui peningkatan penguasaan konsep. Uji hipotesis dalam penelitian ini menggunakan uji *Paired Sample t Test* menggunakan aplikasi SPSS 25. Berdasarkan data yang diperoleh sig.2tailed 0,000 < 0,05 sehingga dapat disimpulkan bahwa penggunaan aplikasi phet simulation berbasis STEM-PBL efektif terhadap peningkatan pemahaman konsep mahasiswa.

Kata kunci: Penguasaan Konsep; Phet Simulation; STEM-PBL

INTRODUCTION

The basic concept of natural science is a compulsory subject that must be mastered by semester 1 students of the PGMI Study Program at the Islamic University of Lamongan. One of the aims of students studying the basic concepts of science is to develop knowledge, skills, and self-confidence so that they can apply the concepts acquired in everyday life. One of the materials in the basic science concept course is dynamic electricity. The concept of dynamic electricity is a material that is generally difficult to learn because in its application it feels abstract, moreover, not all PGMI Study Program students come from the science department.

Based on the results of observations, students find it difficult when the concept of dynamic electricity is applied through questions related to everyday life. Even though science material (physics) is a subject that is considered difficult for students in high school, most students can still easily accept the knowledge provided, but it is difficult to apply this knowledge flexibly in solving problems in everyday life (Warimun, 2012).So far, the learning model used is only in the form of conveying information by lecturers, so concepts are only transferred to students so and the impact is a lack of mastery of student concepts. According to Krathwohl (2002), to master the

Submitted: 18 November 2022 Accepted: 5 Desember 2022 Published: 30 Desember 2022

concept of material, students must master the six categories of cognitive processes in Bloom's taxonomy namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and create (C6).

The limitations of laboratory equipment and the lack of use of laboratory equipment are the umpteenth reason that makes it difficult for students to interpret the material received. According to Emda (2014), a laboratory must have complete equipment for practicum needs, a laboratory as a place to carry out practicum, measurement, research, and scientific research which functions in proving an abstract concept to increase students' curiosity and interpret the concepts received.

Based on the problems that have been described, it is necessary to have learning innovations, one of which is by using a virtual laboratory. The use of virtual laboratories can increase students' motivation to learn (Karagoz, *et,al*, 2010). One of the virtual laboratory media is Physics Education Technology (PhET) Simulation. Ramadani & Nana (2020) states that learning that is carried out with the help of Phet simulation can support students' understanding of concepts so that they can master the material provided. The Phet Simulation application has several advantages, it can be used on computers and cellphones because it can be connected to an internet network or without an internet network (Arifin, *et, al*, 2022). Phet Simulation is a fun software based on discovery and can be used to clarify physical concepts and abstract phenomena (Rochman & Madlazim, 2013). PhET can be used for practicum activities which can save time but do not eliminate the objective of the practicum it self (Astuti & Handayani, 2018).

The use of PhET simulation can be applied in learning with an integrative approach that uses several disciplines. Science, Technology, Engineering, and Mathematics (STEM)-Problem Based Learning (PBL) is a new approach that integrates more than one discipline. PBL is a problem-based learning model, while STEM is a collection of various disciplines that are closely related to each other so that students can have provisions in social life following the STEM field of science (Mayasari, dkk, 2014; Nugraha, dkk, 2017). The purpose of the PBL learning model is to develop the basics of substantial knowledge by positioning students as active problem solvers who are confronted with situations (ill-structured problems) so that students get the opportunity to learn how to learn (Simanjuntak, 2014). Simanjuntak (2014) in his research stated that during the learning process using the PBL model, students were emphasized to make conceptual discoveries. In general, STEM itself when applied in learning can encourage students to design, develop, and utilize technology, and can hone cognitive, affective, and manipulative abilities and be able to apply their knowledge (Ariyatun & Octavianelis, 2020; Capraro, *et al*, 2013).

It is felt necessary to overcome students' lack of mastery of the concept of dynamic electricity in basic science concepts courses by testing the use of the STEM-PBL-based Phet simulation application to improve students' understanding of concepts.

METHODS

This type of research is an experiment with a quasi-experimental research design in the form of one group pretest-posttest. In this study, there was only one experimental group that was given a pretest before being given treatment by applying STEM-PBL based Phet simulation, and after the treatment was given a posttest to see the level of student's mastery of concepts. The subjects of this study were 35 of the Freshman. As for the research design framework (Sugiyono, 2016), as follows:

O1 X O2

Information:
O1 = Pre-Test ability to master the concept
X = Treatment using the STEM-PBL-based Phet Simulation application
O2 = Post-Test ability to master the concept

The data collection technique used a student concept understanding test which had previously been validated and calculated for reliability. While supporting data with observation and documentation of student activities during learning activities. The data analysis method used to determine the effectiveness of using the STEM-PBL-based Phet simulation application for understanding the concept is by using the paired sample t-test, previously the data was tested using the Smirnov-Kolmogorov normality test through the SPSS 25 application.

RESULT AND DISCUSSION

Applying the basic science concepts on the topic of dynamic electricity using the STEM (Science, Technology, Engineering, and Mathematics)-based phet simulation application - PBL (Problem Based Learning) is an alternative to increasing students' understanding of concepts. Technology in the form of Phet simulation supporting tools helps students understand the concept of material. Students are trained to design, assemble, and understand procedures in solving a given problem. While mathematics itself is a tool used to simplify the concept of science itself in a more systematic and mathematical form.

Table 1. Application of STEM in learning

Component	Explanation
Sains	Dynamic Electricity, Electrical Circuits
Technology	Use of Phet Simulations
Engineering	Design and manufacture Electrical Circuits in Miniature Houses
Mathematics	Designing Energy Efficient Electrical Circuits

Table 2. Learning Stages Using the STEM-PBL-based Phet Simulation Application

Step	Learning Activities	Chategory
Asking Questions and Defining the Problem	1. Educators ask questions about phenomena or events that are related to electrical circuits that are close to everyday life. 2. Students clarify the problem and try to solve the problem	Science
Do the Hypothesis	1. Educators guide students to carry out hypotheses in order to develop an explanation of the phenomena that occur using phet simulation 2. Students carry out hypotheses observing circuits in phet simulation	Technologi
Analyse and Interpret Data	Students analyze the observed data obtained and after the data is analyzed then students design an electrical circuit using phet simulation which is then applied to the design of miniature houses	Engineering
Uses Math and Computational Thinking	Students use mathematics to calculate the current flowing in electrical circuits and use problem-solving methods in analyzing the data obtained to obtain energy-efficient electrical circuits.	Mathematich

Students' mastery of concept skills is obtained through tests using valid and reliable pretest and posttest dynamic electricity subject matter instruments. The recapitulation of the results of

mastering the concept of semester 1 students who teach basic science concepts courses is presented in Table 1.

Table 3. Average results of mastering the concept of dynamic electricity

Component	Average Score		N-gain	Category
	Pretest	Posttest		
Average	36	82	0.71	High
Highest Score	77	93	0.69	medium
Lowest Score	23	63	0.52	Medium

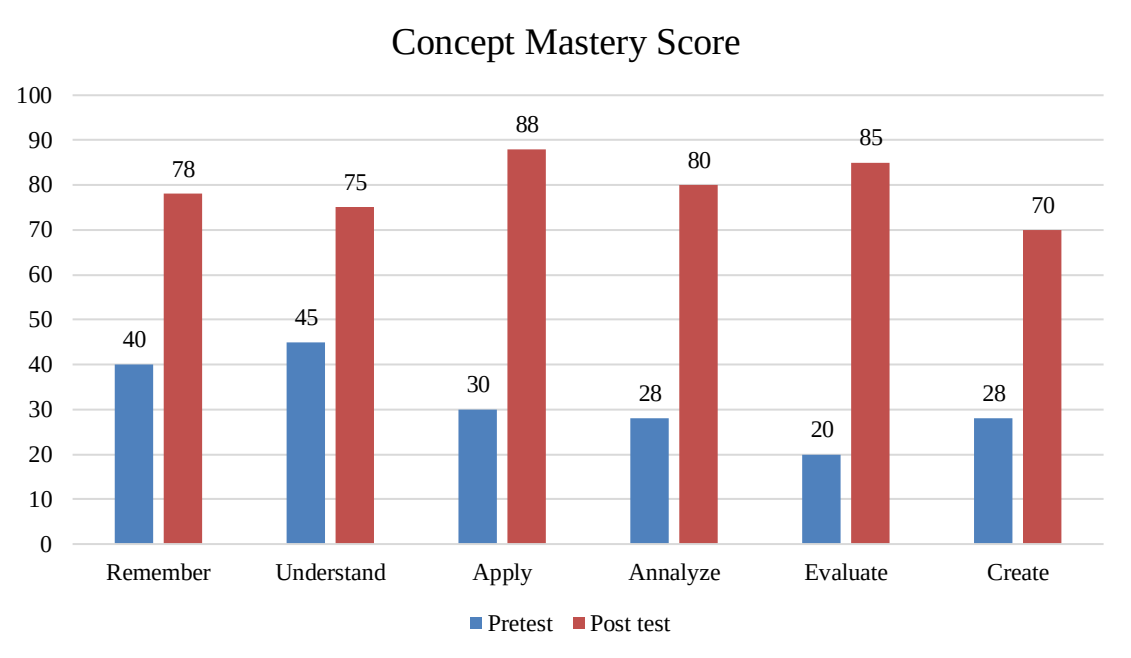
Based on table 3, shows that there was an increase in the pretest and post-test students' concept understanding scores which were measured using questions developed based on indicators of conceptual understanding which included 6 aspects namely remembering, understanding, applying, analyzing, evaluating, and creating. The successful use of the STEM PBL-based Phet application has a positive effect on students' ability to understand the concept of dynamic electricity. The visualization presented by the Phet Simulation application is easy to understand so it makes students' cognitive abilities stronger. According to Rochman and Madlazim in Abdul (2019) This phet simulation is a fun and discovery-based interactive simulation medium and can be used to clarify certain physical concepts or phenomena.

In using the STEM PBL-based phet simulation application, students are provided with worksheets that ask students to hypothesize and analyze the given problem, apply phet then construct it in a concrete project so that students' thinking skills continue to develop and, in the end, students can interpret, relate between events from the simulation using the phet simulation application so that concepts are awakened in students. This is following research conducted by Abdi, dkk (2021) that the PHet simulation helps students by displaying visualizations that enable students to describe an abstract theory, thereby making students interested in learning physics.

Figure 1. Students use phet simulation to construct energy-efficient electrical circuits

Figure 2. Students construct a series that has been arranged using phet simulation to become a project

The use of the STEM PBL-based Phet simulation application is an effective way to construct students' conceptual understanding by maintaining the integration of science, technology, mathematics, and engineering. STEM integration with PBL makes it possible to actualize environmental literacy and student creativity (Farwati, et al, 2017). If it is interpreted on a graph of student mastery of concepts based on indicators of mastery of concepts, it is presented in Graph 1



Graph 1. Data on Concept Mastery Aspects

From the analysis that has been carried out, an average pretest score of 36 is obtained and an average posttest score is 82. So a gain score of 0.71 is obtained in the high category. The highest average score of concept mastery occurs in the applying indicator. This is because, through learning using the Phet simulation application, students independently find concepts, and tinker with existing content in Phet such as using the required resistance and voltage, so students will gain a lot of experience and make learning more meaningful and then be able to apply the concept. that they understand to apply. In line with the opinion expressed by Moore, dkk (2014) that the use of the simulation allows students to gain meaningful experiences and can raise students' curiosity about the concepts they are studying.

Other indicators that also received significant improvements, namely evaluating and analyzing. Through STEM PBL-based learning, students are trained to think critically by solving a problem, students can make a good interpretation of the data obtained when using the phet simulation application. This is in line with what was stated by Putri, dkk (2020) that learning using STEM PBL can facilitate students to always be critical in discovering concepts and linking their experiences with the material being studied. Han, dkk (2015) also mentioned that with STEM PBL students are required to solve real-world problems and engage in ill-defined tasks to become well-defined outcomes through collaboration.

The creation indicator gets a post-test score with the lowest average. This is because in principle the activity of creating has a higher level of difficulty compared to other aspects of cognition (remembering, understanding, applying, analyzing, and evaluating). When students construct electrical circuits in miniature houses that are done in groups, students only rely on colleagues in their groups. So when given questions related to C6 abilities, the student scores have not increased much.

Furthermore, hypothesis testing was carried out using the paired sample t-test with the help of IBM SPSS. Based on the tests performed, the output results are presented in table 4

Table 4. Test result of paired sampel t test mastery of the concept

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	pretest - posttest	-46.257	12.940	2.187	-50.702	-41.812	-21.149	34	.000

The results obtained a significant value of 0.000 > 0.05 so it can be concluded that the use of the STEM PBL-based phet simulation application is effective in increasing students' understanding of concepts. This is in line with research conducted by Rizkiana & Apriani (2020) that students who were taught using PhET had a better understanding of concepts than students who were taught without using PhET.

CONCLUSION AND SUGGESTIONS

Based on the results of this study, it can be concluded that the use of the STEM PBL-based PHET simulation application in learning the basic science concepts of electrical circuit material is effective in increasing students' conceptual understanding with a sig value of 0.000. Suggestions from the conclusions that can be conveyed in this study are, in implementing the use of the PHET simulation application, careful preparation is needed and planning learning activities so that students are more motivated, and further research is needed regarding student responses to the use of STEM PBL-based phet simulation.

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